Survey of Northern Abalone, *Haliotis kamtschatkana,* Populations in Lotbinière Bay, British Columbia, March 2000 [Revised]

B.G. Lucas, A. Campbell, and D. Brouwer

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
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SURVEY OF NORTHERN ABALONE, *Haliotis kamtschatkana*, POPULATIONS IN LOTBINIÈRE BAY, BRITISH COLUMBIA, MARCH 2000 [REVISED]

by

B.G. Lucas, A. Campbell, and D. Brouwer

Fisheries and Oceans Canada

Science Branch, Pacific Region

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Nanaimo, British Columbia

V9T 6N7

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ABSTRACT

Lucas, B.G., A. Campbell, and D. Brouwer. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations in Lotbinière Bay, British Columbia, March 2000. [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2621: 11 p.

A survey was conducted, during March 23 – 27, 2000, to provide an estimate of population numbers of mature emergent northern abalone in Lotbinière Bay, British Columbia, an area where abalone were historically abundant. Abalone shell lengths (SL) ranged from 19 to 130 mm. The estimated mean density for abalone of all sizes was 0.29/m^2. The estimated mean density for abalone 90 – 110 mm SL was 0.08/m^2. The estimated mean total population number (and 90% confidence interval) of emergent abalone for all sizes was 1,786,000 (978,000 – 2,593,000). The mean total population number (and 90% confidence interval) of emergent abalone in the 90 – 110 mm SL size range was estimated for Lotbinière Bay to be 477,000 (261,000 – 693,000).

RÉSUMÉ

Lucas, B.G., A. Campbell, and D. Brouwer. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations in Lotbinière Bay, British Columbia, March 2000. [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2621: 11 p.

Un recensement a été effectué au cours de la période comprise entre le 23 et le 27 mars 2000 pour dénombrer les populations d'ormeaux nordiques adultes dans la baie Lotbinière (Colombie-Britannique), secteur connu pour ses importantes populations d'ormeaux. La taille des coquilles d'ormeaux trouvés dans le secteur variait entre 19 et 130 mm, et la densité moyenne estimative des effectifs, toutes tailles confondues, était de 0,29/m^2. La densité moyenne des effectifs dont la taille était comprise entre 90 mm et 110 mm était de 0,08/m^2. La population moyenne totale (selon un intervalle de confiance de 90 %), toutes tailles confondues, a été établie à 1 786 000 (entre 978 000 et 2 593 000). La population totale moyenne (selon un intervalle de confiance de 90 %), pour les effectifs dont la taille était comprise entre 90 et 110 mm a été établie à 477 000 (entre 261 000 et 693 000) dans la baie Lotbinière.

INTRODUCTION

Northern abalone, *Haliotis kamtschatkana*, populations have declined in British Columbia (B.C.), despite complete closure of the fishery since 1990 for conservation purposes. Post-harvest surveys indicated that abalone densities were still well below levels recommended to ensure sustainable populations (Breen 1986, Campbell et al. 1998). The future of *H. kamtschatkana* was sufficiently uncertain that in April 1999 this species was declared "Threatened" by COSEWIC (Committee on the Status of Endangered Wildlife in Canada).

Fisheries and Oceans Canada (DFO), in cooperation with coastal communities and other interested stakeholders, has begun an initiative to rehabilitate abalone stocks in B.C. Collection of broodstock will be required to implement the first step in this program, which is to develop aquaculture technology for this species.

To estimate abalone stocks in areas of interest, an independent assessment using conventional survey methodology was required. Only emergent abalone were surveyed to provide a minimum estimate of mature adult population numbers; cryptic abalone were not surveyed in this census.

The objectives of this study were to determine densities, size frequencies, and population numbers of mature emergent northern abalone using standard survey methods.

MATERIALS AND METHODS

FIELD METHODS

This survey was conducted March 23 – 27, 2000 in Lotbinière Bay, southeast Estevan Group, central coast of B.C. (Figure 1). The survey area was selected to include areas where abalone were historically abundant. The transect survey method (Cripps and Campbell 1998) was adapted for sampling a large bay, and used for this study. Initial random positions within the bay, where the population was to be estimated, were generated using X and Y coordinates and drawn on a nautical chart. Any potential transects falling on land or in water > 7 m depth were discarded. The primary sampling unit was a "transect", made up of a cluster of secondary units. Each transect was 1 m wide and 20 m in length. Prior to entering the water, a 20 m lead line transect was laid from the boat along the current, to minimize the lead line's entanglement with kelp. Transects were surveyed from the deepest end of the lead line to the shallow end. The secondary sampling unit consisted of a 1 m x 1 m square quadrat that was placed along the transect, 1 m away, to avoid sampling areas disturbed by the lead line placement. Divers flipped the quadrat parallel to the transect line, from deep to shallow, and the number of "emergent" or "exposed" (visible on rocks) abalone, shell length (SL in mm) of each abalone, depth, substrate type, slope, and algal cover was recorded for each quadrat. Any kelp, sea urchins or starfish that might have impeded detection of abalone were removed from the quadrat to ensure all emergent abalone were detected. However, boulders were not moved to examine for cryptic abalone.

Sampling only exposed abalone is an efficient sampling strategy, since the majority of mature abalone (i.e., ≥ 70 mm SL) are exposed (Campbell 1996). Every quadrat was sampled completely (i.e., abalone, substrate and algae) in a total of 25 transects.

ANALYTICAL METHODS

To determine the size frequency distribution for an area, the number of abalone in each 5 mm SL size class was divided by the total number of abalone in each area. All gauge depths were converted to depth (m) at datum.

Density estimates were calculated using the methods of Campbell et al. (1999). The estimated mean density, $\bar{d}$ (number/m^2), of abalone was calculated as:

$$\bar{d} = \frac{\sum_t (d_t * L_t)}{\sum_t L_t} \qquad (1)$$

The standard error of the mean density, se_d, was calculated as:

$$se_d = \sqrt{1 - \frac{n}{T}} * \sqrt{\frac{\sum_t (d_t * L_t - \bar{d} * L_t)^2}{n * (n-1) * \bar{L}^2}} \qquad (2)$$

where n is the number of transects, d_t is the mean density (number/m^2) at transect t, L_t is the length of transect t (or area in square metres since each transect is one metre wide), $\bar{L} = \frac{\sum_t L_t}{n}$ is the mean transect length (or mean area in square metres), and T is the total possible number of transects that can be sampled in the surveyed area. The expression $\sqrt{1 - \frac{n}{T}}$ is approximately one, because the number of transects surveyed n is small compared to T. This method accounts for transects of variable length and for a variable proportion of quadrats surveyed along each transect.

To estimate the mean densities for a specific size group (J), e.g., 90 – 110 mm SL, the value d_t was substituted with densities ($P_{t,J}$) in equations 1 and 2. The mean density $P_{t,J}$ of abalone of size group J in transect t was calculated as:

$$P_{t,J} = \frac{\left(N_t * \frac{\sum_{i \in J} m_{t,i}}{M_t} \right)}{S_t} \qquad (3)$$

where J is a subset (e.g., 90 – 100 mm SL) of possible i values representing a range of shell lengths (SL_i), S_t is the number of quadrats surveyed for density estimates in transect t, N_t is the number of abalone counted for density estimates in transect t, $M_t = \sum_i m_{t,i}$ the total number of abalone measured for size in transect t, and $m_{t,i}$ is the number of abalone in size range J of transect t.

The approximate lower 90% confidence interval of the mean density (L90CI) was calculated as:

$$\text{L90CI} = \bar{d} - t_{\alpha/2} * se_d \qquad (4)$$

where n is the number of transects, se_d is the standard error (Equation 2), $\bar{d}$ is the mean abalone density (Equation 1), and $t_{\alpha/2}$ is the critical t-distribution value at degrees of freedom of n-1, where n is the number of transects sampled per area.

The total number of abalone (X) in each abalone bed area was calculated as:

$$X = \bar{d} * A \qquad \text{or} \qquad X = \text{L90CI} * A \qquad (5)$$

where $\bar{d}$ is the estimated mean density, L90CI is the lower 90% confidence interval of the mean density for all sizes or for a particular size group of abalone, and A is the estimated area (m^2) of the surveyed abalone bed. To calculate the area of the bed the following procedure was used. The area of the bay used for initial selection of random positions was calculated after digitising from a nautical chart. The area of all islands within the bay and any areas > 7 m depth were subtracted from the total area of the bay to provide the total area surveyed.

RESULTS

The area surveyed in Lotbinière Bay was exposed to wind and storms, with occasional current and strong tidal flow. The substrate consisted of bedrock, boulders, cobble and gravel, with some sand and shell (Table 1). The surveyed transects included all these substrate types, according to the randomly selected start points, so that the transects surveyed were considered representative of the entire area of the bay used for the population estimate. The slope (angle from horizontal) ranged from 0^o to 30^o. Although spring algal growth had only just begun when these surveys were conducted, there was a moderate cover of large *Nereocystis* and *Macrocystis*

in some areas. The predominant understory species was *Laminaria*, followed by *Agarum*. Articulated corraline algae were common, and encrusting corraline algae were abundant.

The depth surveyed ranged from -0.37 to 7.19 m from datum (Table 2). Twenty five transects were surveyed initially, but 2 transects were outside the area selected for a population estimate, so they were omitted from all analyses. One hundred thirty-one abalone were found in quadrats along the 23 transects in Lotbinière Bay (Tables 2, 3). Seven transects surveyed had no emergent abalone. The maximum density for a transect was 1.4 abalone/m^2. Sizes of abalone surveyed ranged from 19 to 130 mm SL (Figure 2). The size frequency graph shows peaks at both 50 and 90 mm SL. The mean size of emergent abalone was 80 mm SL.

Estimated mean total density of emergent abalone from Lotbinière Bay was 0.29/m^2 (Table 4). The mean population estimate was 1,786,000 emergent abalone in Lotbinière Bay. The mean estimate of the number of abalone in the 90 – 110 mm SL size range was 477,000.

DISCUSSION

There was a wide range of sizes of abalone found in this survey, with both larger and smaller abalone found than in 1997 in the Estevan Group (Campbell et al. 1998), although the mean size was the same for both years. The peaks in size frequency may indicate pulses in recruitment to the population. A conservative estimate of the total population numbers of emergent abalone of all sizes was provided by the lower 90% confidence interval (L90CI), which was 978,000 abalone for Lotbinière Bay. The L90CI for mature emergent abalone 90 – 110 mm SL was 261,000 for Lotbinière Bay. The large uncertainty surrounding the estimated population means results, in part, from the small sample sizes. The lower confidence intervals provide more conservative estimates of population size than the mean estimates.

This survey provides no evidence of recovery of abalone populations since the province-wide closure in 1990. The total abalone densities found during this survey were similar to those found in 1997 in the Estevan Group (0.29/m^2 using the 16-quadrat method), but lower than earlier studies in the area (Campbell et al. 1998). Since these low densities are well below those recommended to ensure sustainable populations (Breen 1986), the removal of any abalone from these areas must be considered with caution.

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Table 1. Habitat summary for abalone transects surveyed in Lotbinière Bay, March 23 – 27, 2000. All areas surveyed had occasional current and high exposure to storms. The most common substrates are listed (1 = first, 2 = second, 3 = third) where substrate code 1 = smooth bedrock, 2 = bedrock with crevices, 3 = boulders, 4 = cobble, 5 = gravel, 6 = pea gravel, 7 = sand, 8 = shell, and 9 = mud. The average slope of the transect is estimated in degrees from horizontal. The algae present are listed by height strata (canopy = tall shading surface reaching, understory = 30 cm – 2 m, turf = 5 cm – 30 cm and bottom cover = < 5 cm) for the most common species (Sp 1) and second most common species (Sp 2) with the estimated percentage of cover (%) for each. AC = articulated coralline, AG = *Agarum*, B = unknown brown, CO = *Costaria*, EN = encrusting corraline, GR = sea grass, H = unknown filamentous, LA = *Laminaria*, MA = *Macrocystis*, NT = *Nereocystis*, PL = *Pleurophycus*, and UL = *Ulva*.

						Algae											
		Substrate			Slope	Canopy		Understory				Turf				Bottom Cover	
Transect	Date	1	2	3	degrees	Sp	%	Sp 1	%	Sp 2	%	Sp 1	%	Sp 2	%	Sp	%
LB-1	Mar 27	5	6	3	0			LA	10			H	10			EN	10
LB-5	Mar 25	2			30	NT	15	LA	20			AC	25	H	3	EN	70
LB-9	Mar 27	1	3	5	2	NT	20	LA	20			UL	5			EN	80
LB-13	Mar 27	5	7	4	0											EN	100
LB-14	Mar 27	7	6		0			LA	2			GR	50				
LB-16	Mar 23	1	3	5	2			LA	80			AC	70			EN	50
LB-19	Mar 25	1	3	5	2			LA	20			AC	70			EN	100
LB-25	Mar 25	2	3	4	30							AC	5	H	1	EN	70
LB-27	Mar 27	4	7		0	MA	80	AG	20	LA	10	AC	10			EN	60
LB-30	Mar 23	8	4	5	15			LA	30	AG	20					EN	25
LB-34	Mar 27	5	4	3	2			LA	50	AG	50	H	5			EN	80
LB-36	Mar 27	4	5	7	2	MA	50	LA	40			AC	30			EN	50
LB-38	Mar 23	3	4		0			LA	10			H	30			EN	30
LB-41	Mar 25	3	4	5	0			LA	30							EN	75
LB-44	Mar 25	1	5	4	0			LA	10							EN	80
LB-47	Mar 25	5	4	3	0	MA	10	LA	10							EN	5
LB-48	Mar 25	2	1		0							AC	40	H	20	EN	100
LB-49	Mar 27	7	4		0			LA	10	AG	10	B	20				
LB-56	Mar 27	4	7	1	5	MA	90	AG	30	LA	10					EN	10
LB-57	Mar 27	4	5		3			LA	20	CO	20	H	30				
LB-59	Mar 27	4	3		2							UL	30	H	30	EN	50
LB-62	Mar 27	4	3	5	0	NT	10	LA	70							EN	80
LB-63	Mar 23	3	4	5	0			LA	80	PL	5	AC	50			EN	50

Table 2. Dive summary for abalone transects surveyed in Lotbinière Bay, March 23 – 27, 2000.

		Time		Bottom	Depth (m)		Number of	Total #	Density
Transect	Date	Start	Finish	Time	Min	Max	Quadrats	of Abalone	(#/m^2)
LB-1	Mar 27	11:06	11:20	0:14	0.15	0.52	20	0	0.00
LB-5	Mar 25	12:30	12:50	0:20	1.62	2.96	20	9	0.45
LB-9	Mar 27	16:35	16:53	0:18	2.32	2.93	20	10	0.50
LB-13	Mar 27	17:10	17:22	0:12	2.44	2.50	20	1	0.05
LB-14	Mar 27	11:29	11:35	0:06	1.19	1.22	20	0	0.00
LB-16	Mar 23	10:56	11:27	0:31	0.06	1.83	20	1	0.05
LB-19	Mar 25	14:30	14:54	0:24	-0.37	2.50	20	2	0.10
LB-25	Mar 25	11:05	11:20	0:15	3.23	7.19	20	4	0.20
LB-27	Mar 27	15:00	15:12	0:12	1.74	1.83	20	0	0.00
LB-30	Mar 23	14:33	14:47	0:14	5.33	5.43	20	0	0.00
LB-34	Mar 27	15:25	15:37	0:12	-0.27	1.95	20	0	0.00
LB-36	Mar 27	14:05	14:30	0:25	1.43	2.23	20	7	0.35
LB-38	Mar 23	15:12	15:39	0:27	5.88	6.49	20	17	0.85
LB-41	Mar 25	15:38	16:00	0:22	4.51	4.63	20	15	0.75
LB-44	Mar 25	15:07	15:26	0:19	5.33	5.49	20	5	0.25
LB-47	Mar 25	16:22	16:53	0:31	1.71	1.71	20	10	0.50
LB-48	Mar 25	11:40	12:08	0:28	0.67	2.13	20	28	1.40
LB-49	Mar 27	12:22	12:33	0:11	5.27	5.27	20	0	0.00
LB-56	Mar 27	12:40	13:08	0:28	2.16	5.88	20	2	0.10
LB-57	Mar 27	14:35	14:50	0:15	1.10	2.23	20	0	0.00
LB-59	Mar 27	11:57	12:10	0:13	3.41	3.72	20	13	0.65
LB-62	Mar 27	16:00	16:21	0:21	1.86	1.98	20	6	0.30
LB-63	Mar 23	11:56	12:25	0:29	1.49	3.23	20	1	0.05

Table 3. Summary statistics and area surveyed for transect survey of emergent abalone from Lotbinière Bay, March 23 – 27, 2000. Values in brackets are standard errors.

Details per transect	Lotbinière Bay
Dates	March 23 - 27
Number of transects	23
Mean transect length (m) & number of quadrats	20 (0)
Mean depth (m)	2.82 (0.09)
Mean minutes/transect	19.43 (1.50)
Mean minutes/quadrat	0.97 (0.08)
Area surveyed (km^2)	6.27

Table 4. Mean densities (number/m^2) and populations estimates of emergent abalone from Lotbinière Bay, March 23 – 27, 2000. Values in brackets are 90% confidence intervals, # = number.

Population parameter	Lotbinière Bay
Mean density all sizes (number/m^2)	0.29 (0.16 - 0.41)
Mean density 90 - 110 mm SL (number/m^2)	0.08 (0.04 - 0.11)
Total population all sizes (x 1000)	1786 (978 - 2593)
Population 90 - 110 mm SL (x 1000)	477 (261 - 693)

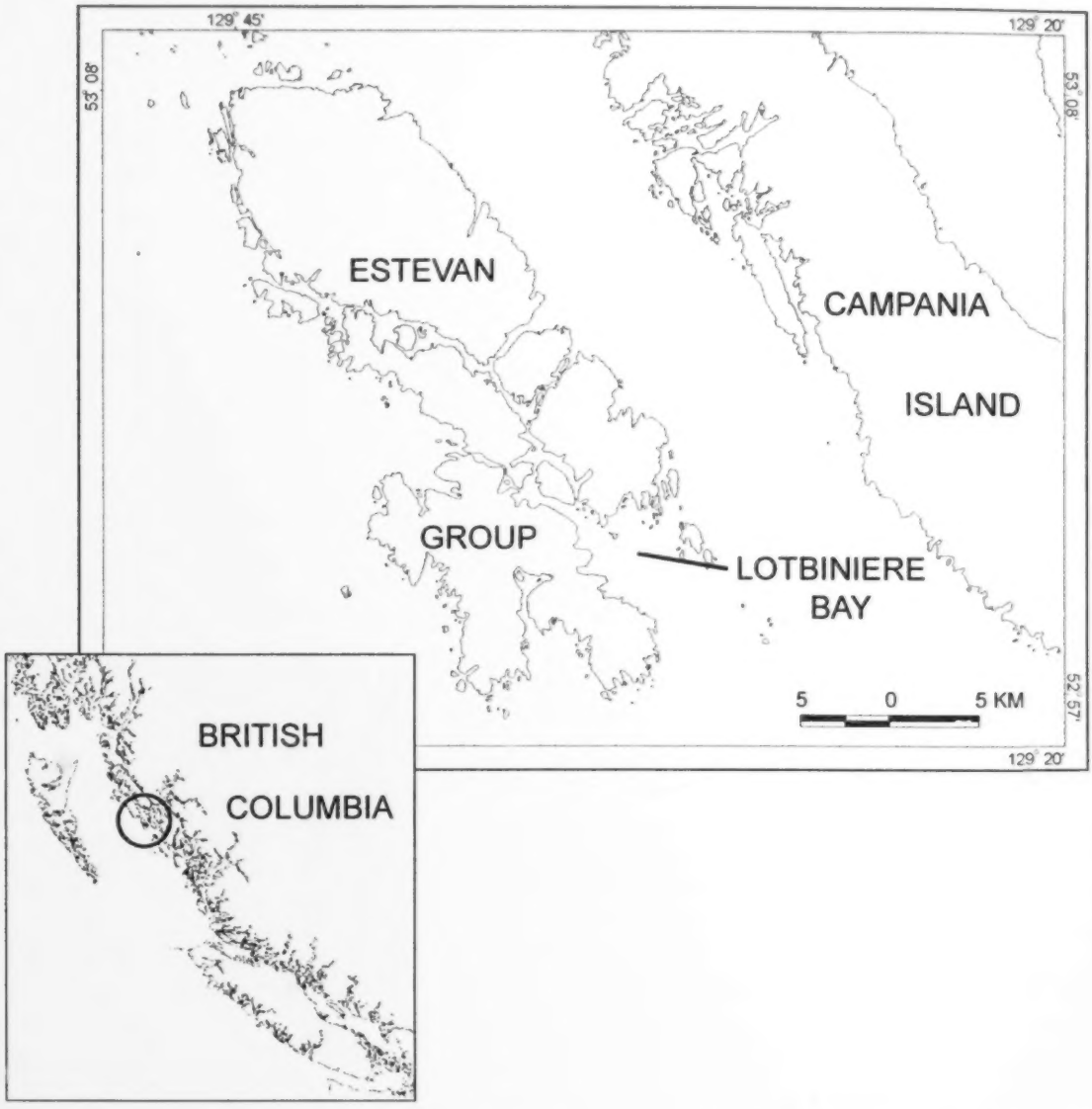

Figure 1. Abalone were surveyed in Lotbinière Bay, March 23 – 27, 2000. The inset shows the area of British Columbia detailed on the map.

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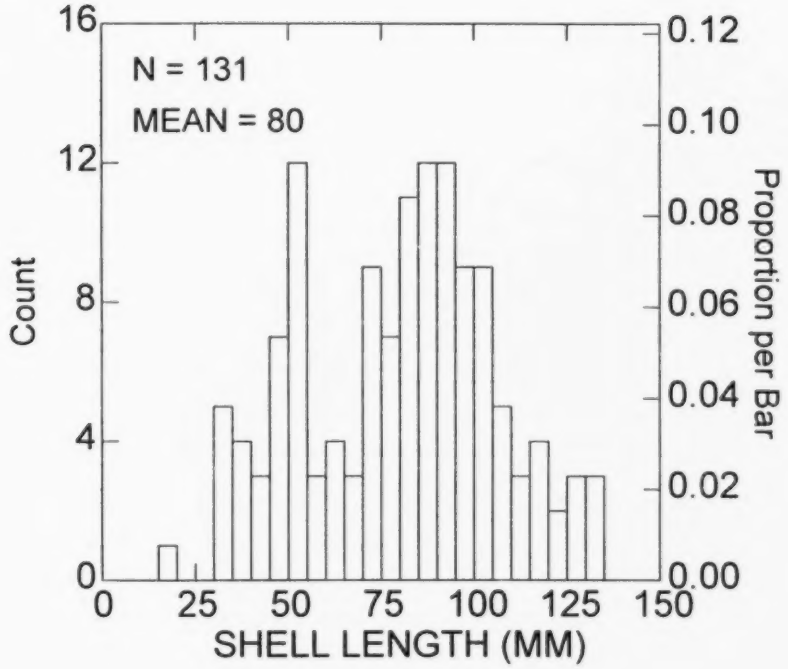

Figure 2. Size frequencies of emergent abalone found in quadrats during dive surveys in Lotbinière Bay, March 23 – 27, 2000. Number of abalone (N) and mean shell length in mm are shown.